

# Minería de datos y Patrones

Version 2024-I

## Local Binary Patterns

[ Capítulo 2 ]

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Universidad Popular del Cesar

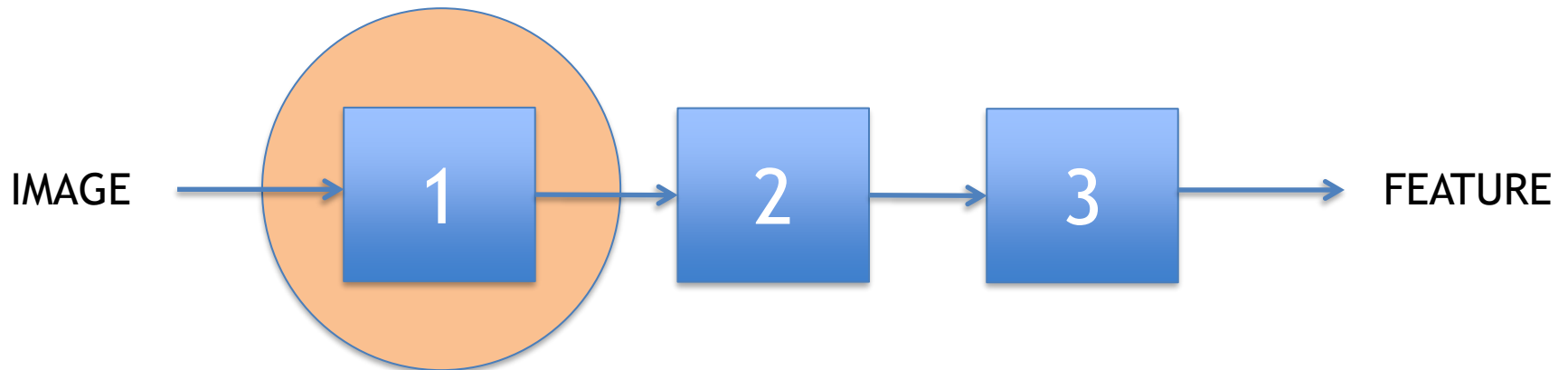
# Local Binary Patterns

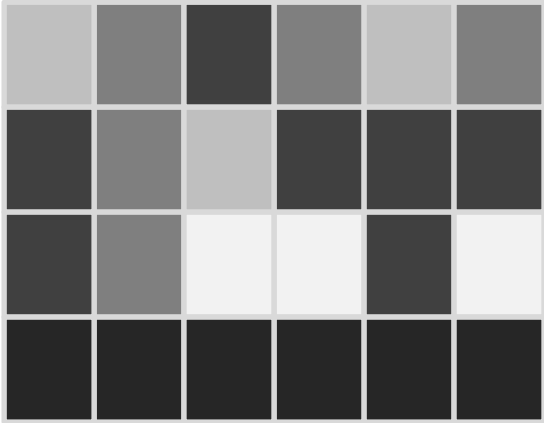
1. Coding
2. Mapping
3. Histogram



# Local Binary Patterns

1. Coding
2. Mapping
3. Histogram





|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |  |  |
|---|--|--|
| < |  |  |
|   |  |  |
|   |  |  |



|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |  |  |
|---|--|--|
| 0 |  |  |
|   |  |  |
|   |  |  |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |        |  |
|---|--------|--|
| 0 | $\geq$ |  |
|   |        |  |
|   |        |  |

0: <  
1:  $\geq$

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |   |  |
|---|---|--|
| 0 | 1 |  |
|   |   |  |
|   |   |  |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
|   |   |   |
|   |   |   |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
|   |   | 0 |
|   |   |   |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
|   |   | 0 |
|   |   | 0 |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
|   |   | 0 |
|   | 1 | 0 |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
|   |   | 0 |
| 1 | 1 | 0 |

0: <  
1: ≥



|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
| 1 |   | 0 |
| 1 | 1 | 0 |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

0: <  
1: ≥

|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
| 1 |   | 0 |
| 1 | 1 | 0 |

x

|     |    |    |
|-----|----|----|
| 1   | 2  | 4  |
| 128 | +  | 8  |
| 64  | 32 | 16 |

$$= 2+4+32+64+128 = 230$$

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

0: <  
1: ≥

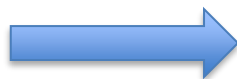
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| 0 | 1 | 1 |
| 1 |   | 0 |
| 1 | 1 | 0 |

x

|     |    |    |
|-----|----|----|
| 1   | 2  | 4  |
| 128 | +  | 8  |
| 64  | 32 | 16 |

$$= 2+4+32+64+128 = 230$$

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



|  |     |  |  |  |  |
|--|-----|--|--|--|--|
|  |     |  |  |  |  |
|  | 230 |  |  |  |  |
|  |     |  |  |  |  |
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|   |   |   |
|---|---|---|
| 4 | 6 | 9 |
| 9 | 6 | 4 |
| 9 | 6 | 2 |

0: <  
1: ≥

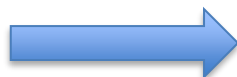
|   |   |   |
|---|---|---|
| 0 | 1 | 1 |
| 1 |   | 0 |
| 1 | 1 | 0 |

x

|     |    |    |
|-----|----|----|
| 1   | 2  | 4  |
| 128 | +  | 8  |
| 64  | 32 | 16 |

$$= 2+4+32+64+128 = 230$$

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



|  |     |   |  |  |  |
|--|-----|---|--|--|--|
|  |     |   |  |  |  |
|  | 230 | ? |  |  |  |
|  |     |   |  |  |  |
|  |     |   |  |  |  |

|   |   |   |
|---|---|---|
| 6 | 9 | 6 |
| 6 | 4 | 9 |
| 6 | 2 | 2 |

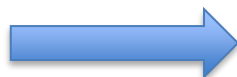
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|  |  |  |

x

|     |    |    |
|-----|----|----|
| 1   | 2  | 4  |
| 128 | +  | 8  |
| 64  | 32 | 16 |

0: <  
1: ≥

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



|  |     |     |  |  |  |
|--|-----|-----|--|--|--|
|  |     |     |  |  |  |
|  | 230 | 207 |  |  |  |
|  |     |     |  |  |  |
|  |     |     |  |  |  |

|   |   |   |
|---|---|---|
| 6 | 9 | 6 |
| 6 | 4 | 9 |
| 6 | 2 | 2 |

0: <  
1: ≥

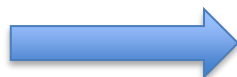
|   |   |   |
|---|---|---|
| 1 | 1 | 1 |
| 1 |   | 1 |
| 1 | 0 | 0 |

x

|     |    |    |
|-----|----|----|
| 1   | 2  | 4  |
| 128 | +  | 8  |
| 64  | 32 | 16 |

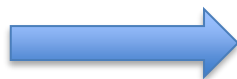
$$= 1+2+4+8+64+128 = 207$$

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



|  |     |     |   |  |  |
|--|-----|-----|---|--|--|
|  |     |     |   |  |  |
|  | 230 | 207 | ? |  |  |
|  |     |     |   |  |  |
|  |     |     |   |  |  |

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



|  |     |     |    |  |  |
|--|-----|-----|----|--|--|
|  |     |     |    |  |  |
|  | 230 | 207 | 25 |  |  |
|  |     |     |    |  |  |
|  |     |     |    |  |  |

|   |   |   |
|---|---|---|
| 9 | 6 | 4 |
| 4 | 9 | 9 |
| 2 | 2 | 9 |

0: <  
1: ≥

|   |   |   |
|---|---|---|
| 1 | 0 | 0 |
| 0 |   | 1 |
| 0 | 0 | 1 |

x

|     |    |    |
|-----|----|----|
| 1   | 2  | 4  |
| 128 | +  | 8  |
| 64  | 32 | 16 |

$$= 1+8+16 = 25$$

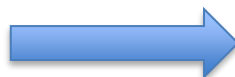


|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



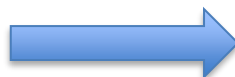
|  |     |     |    |     |  |
|--|-----|-----|----|-----|--|
|  |     |     |    |     |  |
|  | 230 | 207 | 25 | 168 |  |
|  |     |     |    |     |  |
|  |     |     |    |     |  |

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



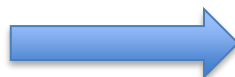
|  |     |     |    |     |  |
|--|-----|-----|----|-----|--|
|  |     |     |    |     |  |
|  | 230 | 207 | 25 | 168 |  |
|  | 243 |     |    |     |  |
|  |     |     |    |     |  |

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



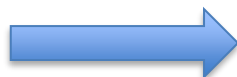
|  |     |     |    |     |  |
|--|-----|-----|----|-----|--|
|  |     |     |    |     |  |
|  | 230 | 207 | 25 | 168 |  |
|  | 243 | 255 |    |     |  |
|  |     |     |    |     |  |

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



|  |     |     |     |     |  |
|--|-----|-----|-----|-----|--|
|  |     |     |     |     |  |
|  | 230 | 207 | 25  | 168 |  |
|  | 243 | 255 | 255 |     |  |
|  |     |     |     |     |  |

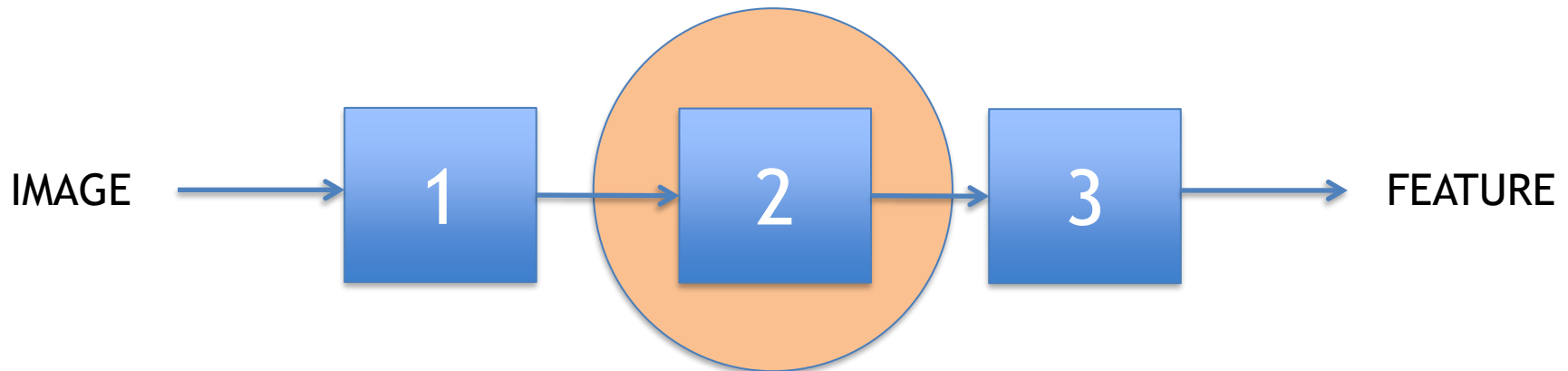
|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |



|  |     |     |     |     |  |
|--|-----|-----|-----|-----|--|
|  |     |     |     |     |  |
|  | 230 | 207 | 25  | 168 |  |
|  | 243 | 255 | 255 | 119 |  |
|  |     |     |     |     |  |

# Local Binary Patterns

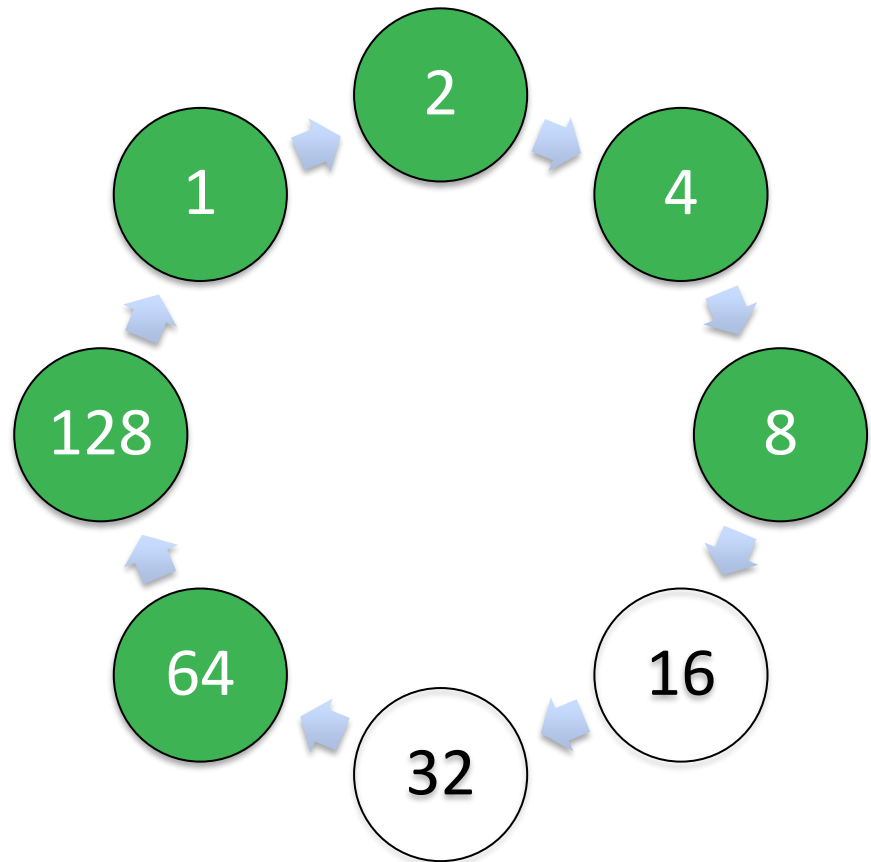
1. Coding
- 2. Mapping**
3. Histogram



|   |   |   |
|---|---|---|
| 6 | 9 | 6 |
| 6 | 4 | 9 |
| 6 | 2 | 2 |



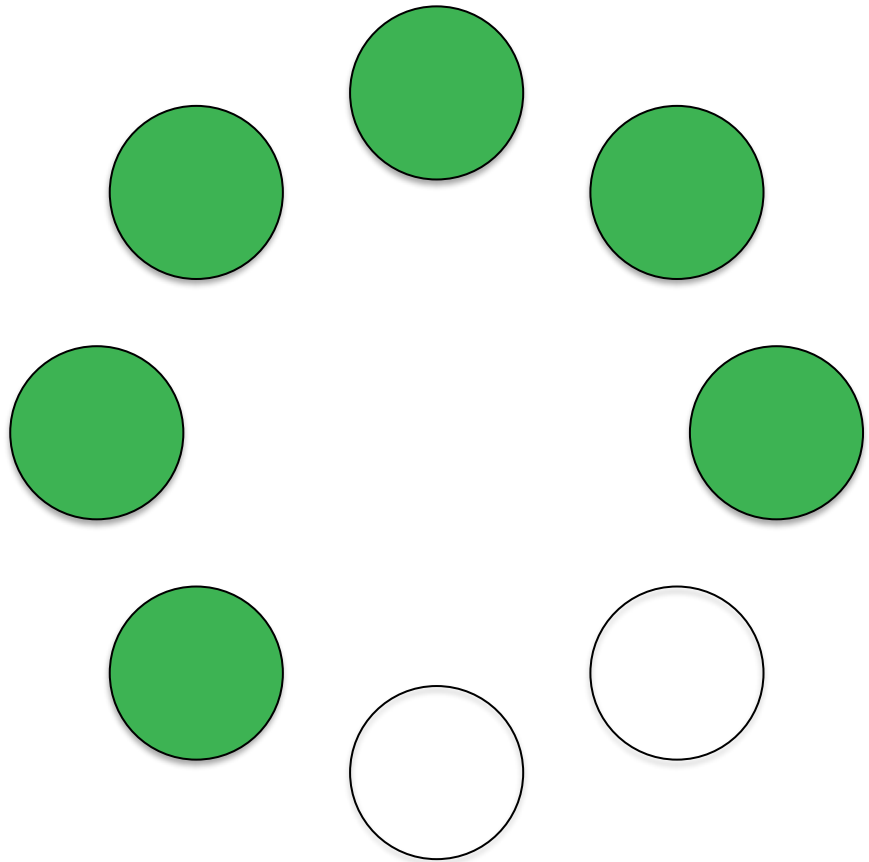
|   |   |   |
|---|---|---|
| 1 | 1 | 1 |
| 1 |   | 1 |
| 1 | 0 | 0 |



|   |   |   |
|---|---|---|
| 6 | 9 | 6 |
| 6 | 4 | 9 |
| 6 | 2 | 2 |



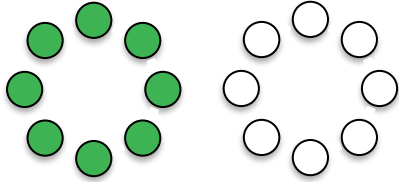
|   |   |   |
|---|---|---|
| 1 | 1 | 1 |
| 1 |   | 1 |
| 1 | 0 | 0 |

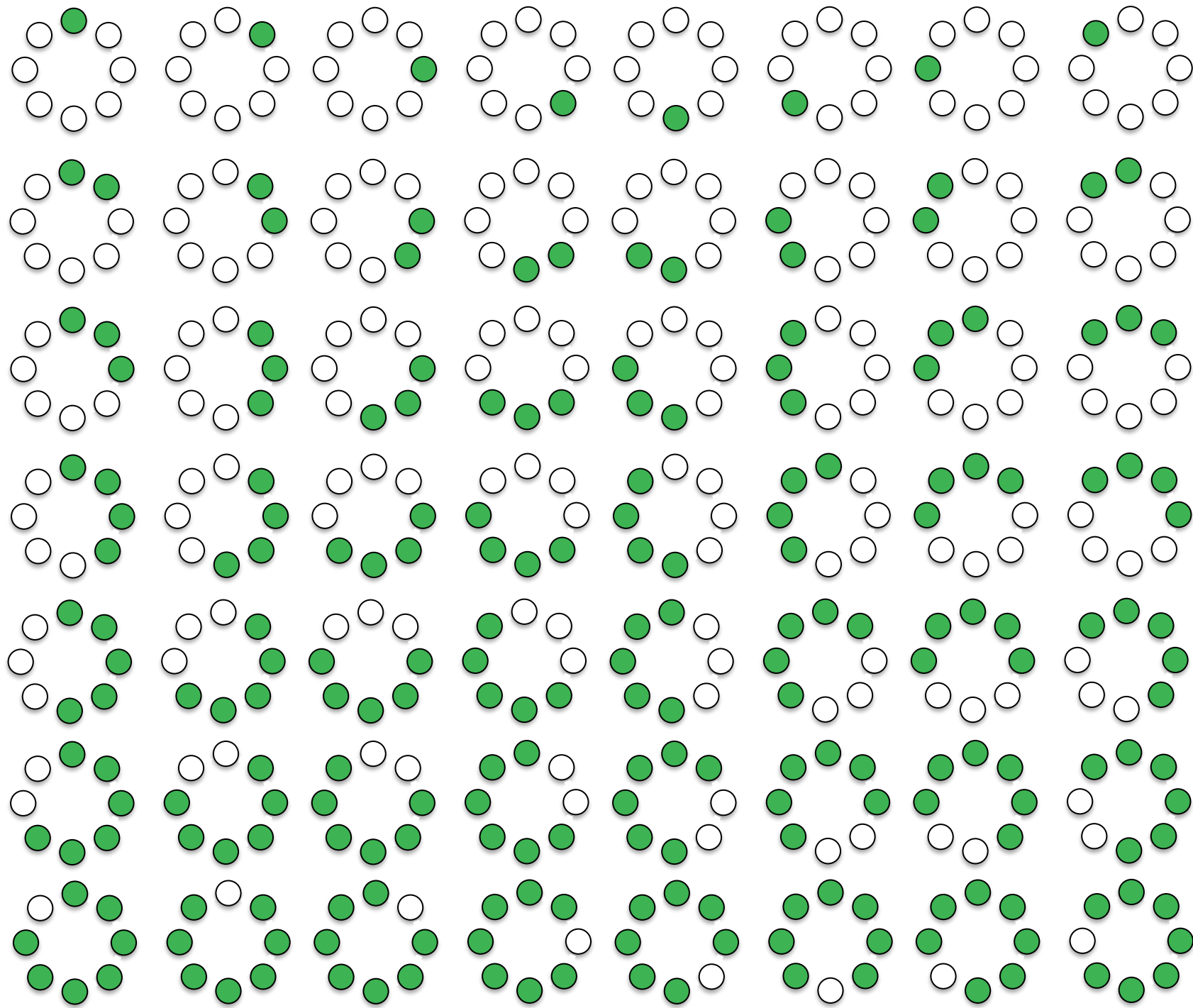




# Uniform patterns

$U = 0$



$$U = 2$$


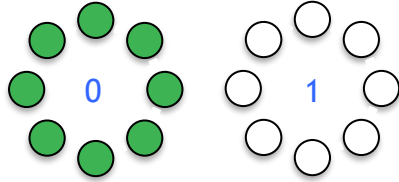
# Uniform patterns

$2 + 56 = 58$   
patterns

$U = 0$

2  
patterns

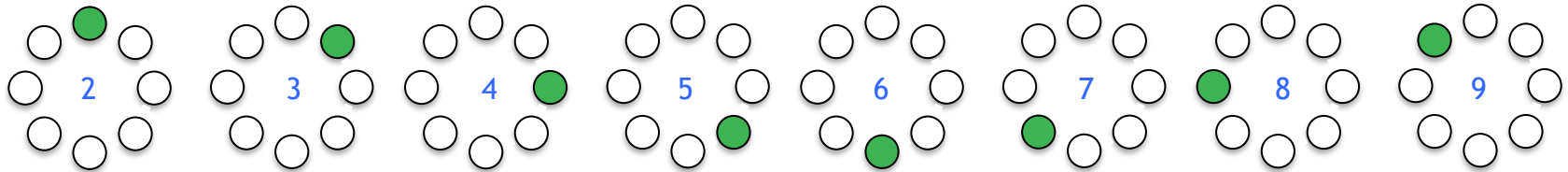
$\{0, 1\}$



$U = 2$

$8 \times 7 = 56$   
patterns

$\{2, 3, \dots, 57\}$



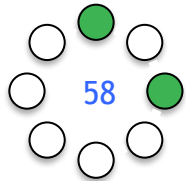
⋮

# Non-uniform patterns

$256 - 58 = 198$   
patterns

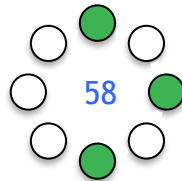
$\{58\}$

$U = 4$



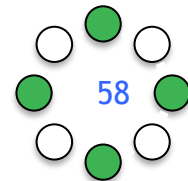
⋮

$U = 6$



⋮

$U = 8$



⋮

|    |    |    |    |    |    |
|----|----|----|----|----|----|
| 4  | 6  | 9  | 6  | 4  | 6  |
| 9  | 6  | 4  | 9  | 9  | 9  |
| 9  | 6  | 2  | 2  | 9  | 2  |
| 10 | 10 | 10 | 10 | 10 | 10 |

IMAGE



|  |     |     |     |     |  |
|--|-----|-----|-----|-----|--|
|  |     |     |     |     |  |
|  | 230 | 207 | 25  | 168 |  |
|  | 243 | 255 | 255 | 119 |  |
|  |     |     |     |     |  |

CODED  
IMAGE

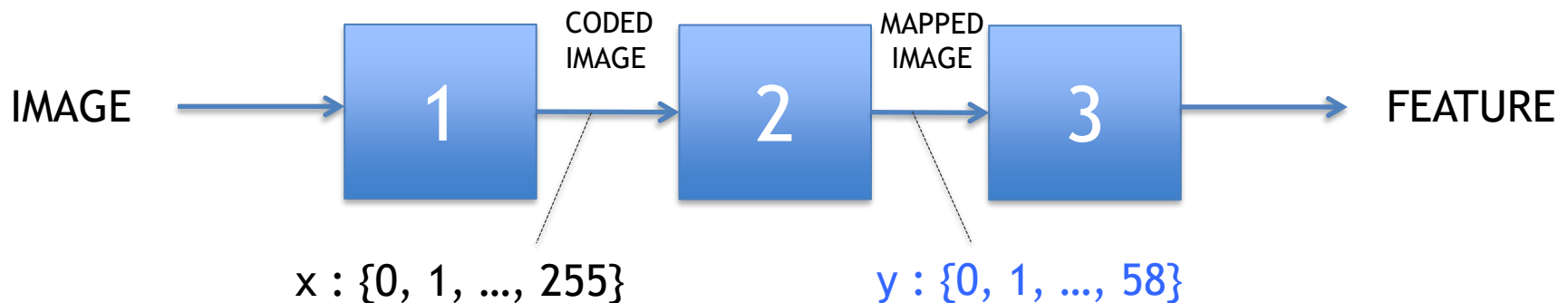


|  |    |    |    |    |  |
|--|----|----|----|----|--|
|  |    |    |    |    |  |
|  | 58 | 46 | 58 | 58 |  |
|  | 23 | 1  | 1  | 58 |  |
|  |    |    |    |    |  |

MAPPED  
IMAGE

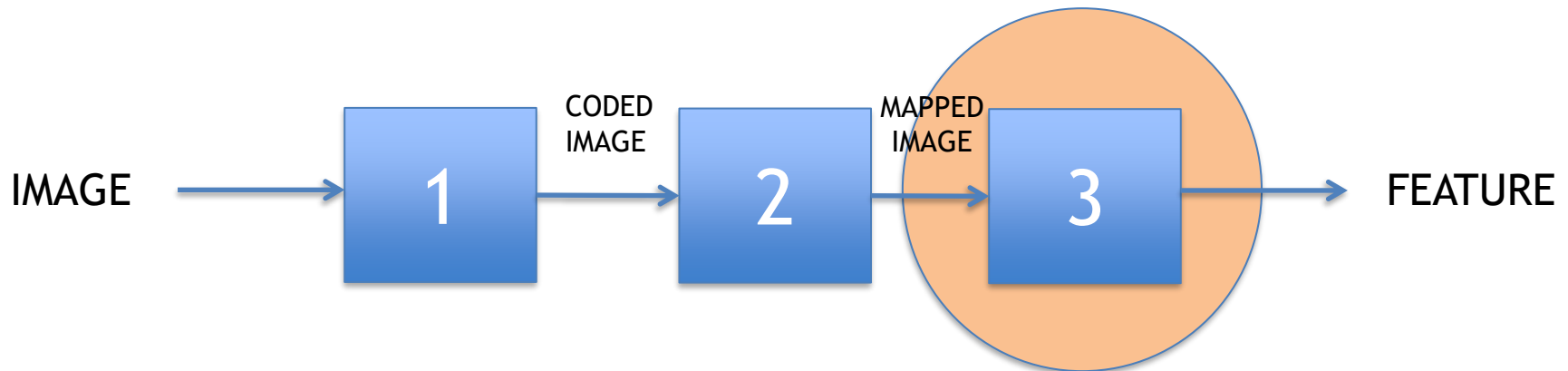
# Local Binary Patterns

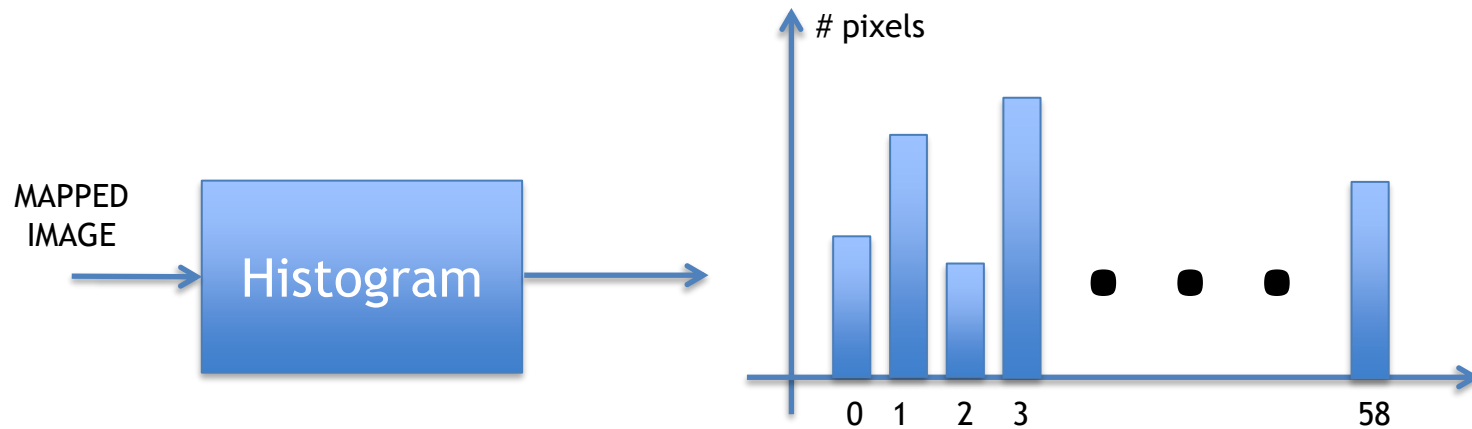
1. Coding
2. Mapping
3. Histogram



# Local Binary Patterns

1. Coding
2. Mapping
3. Histogram



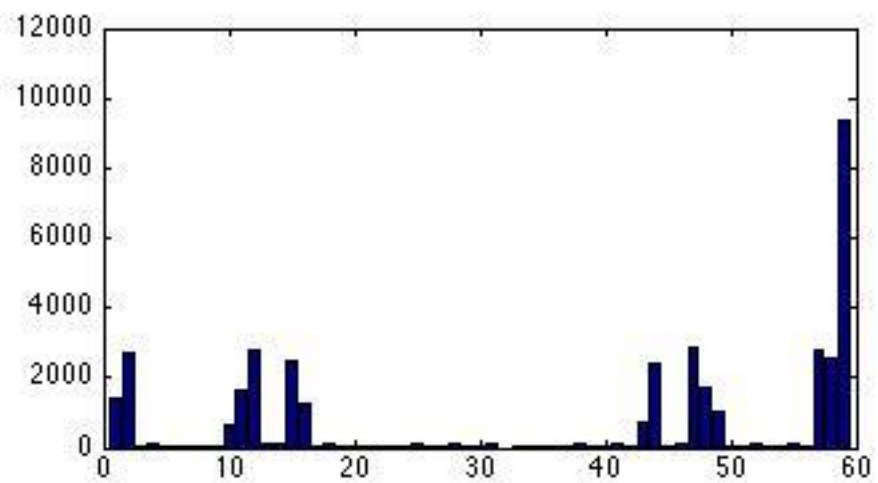
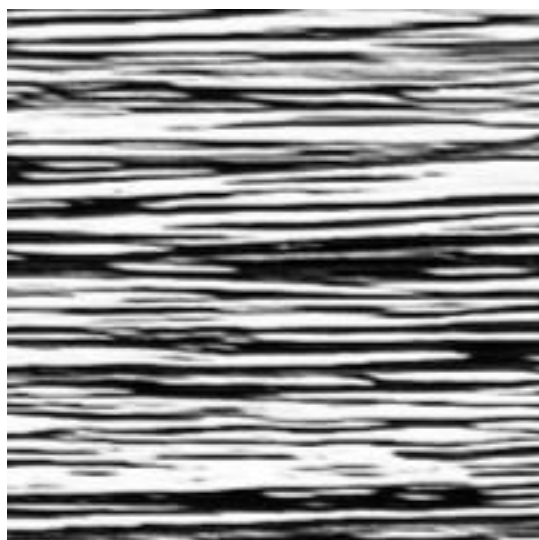
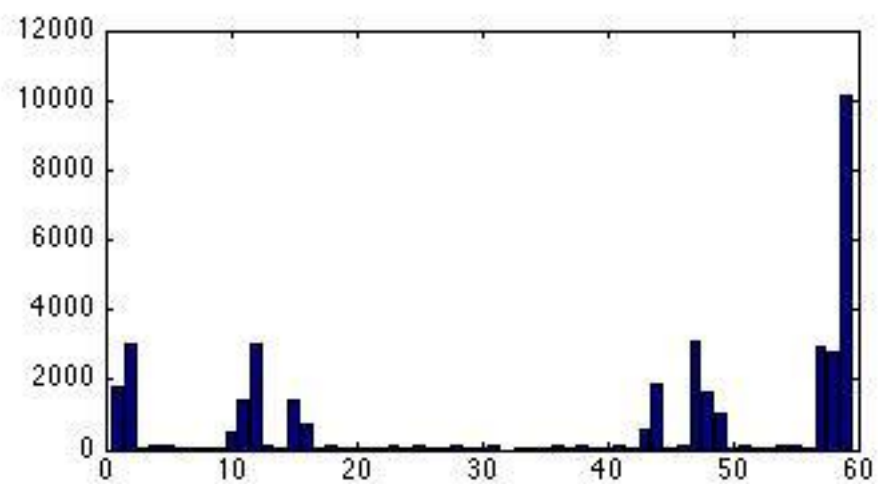
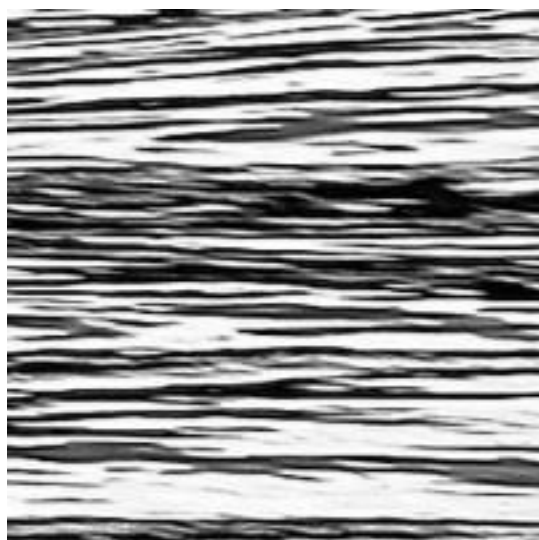


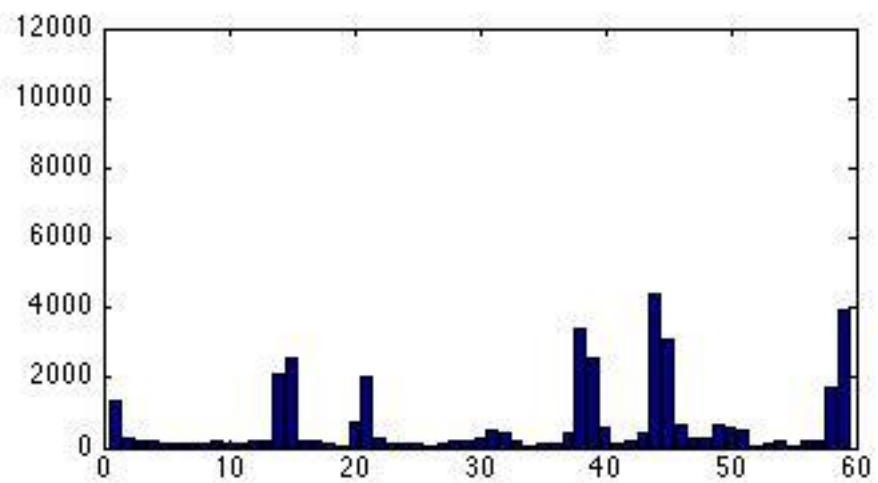
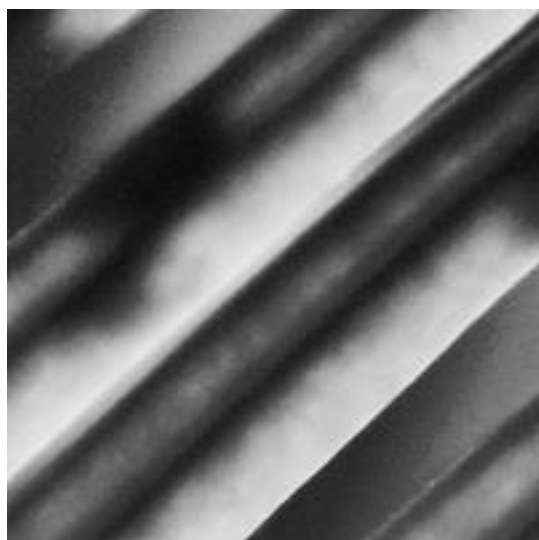
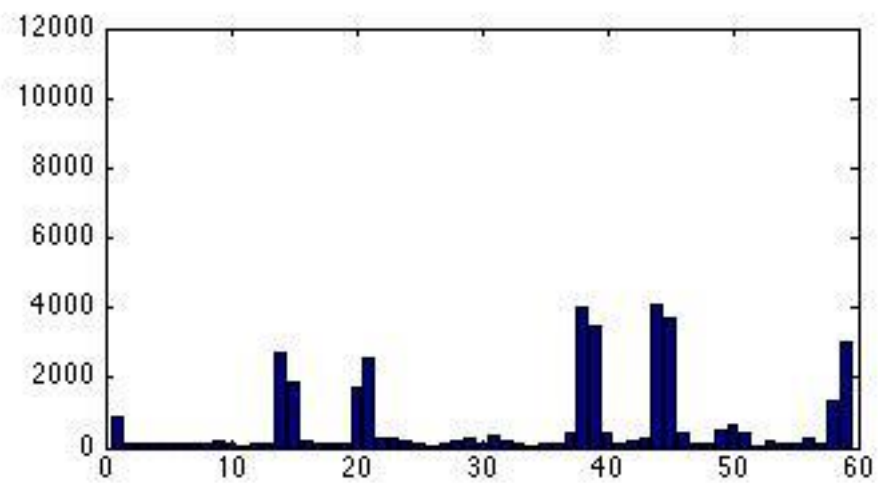
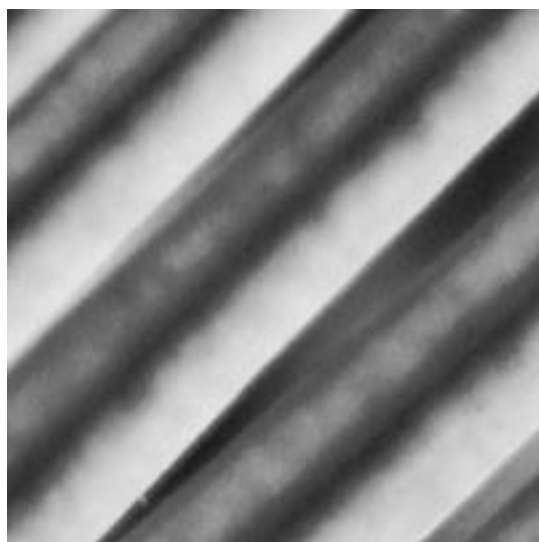
The image is described as a vector of 59 elements. Similar images have similar LBP features!!!

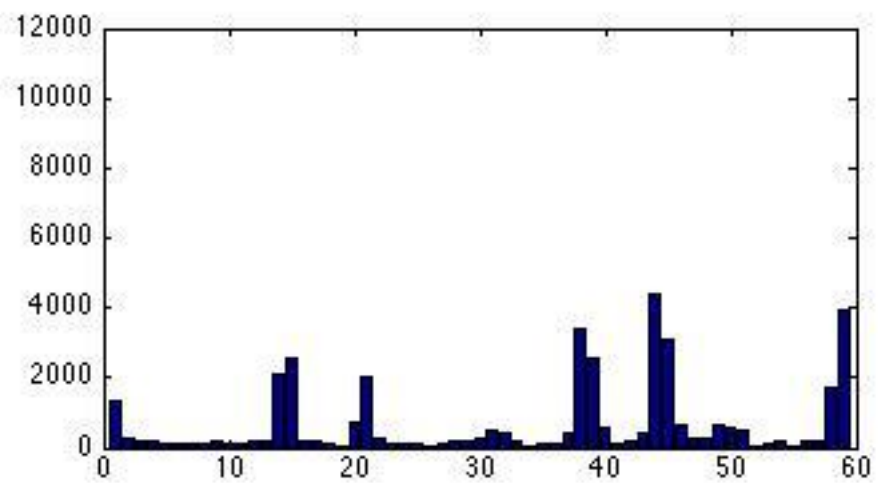
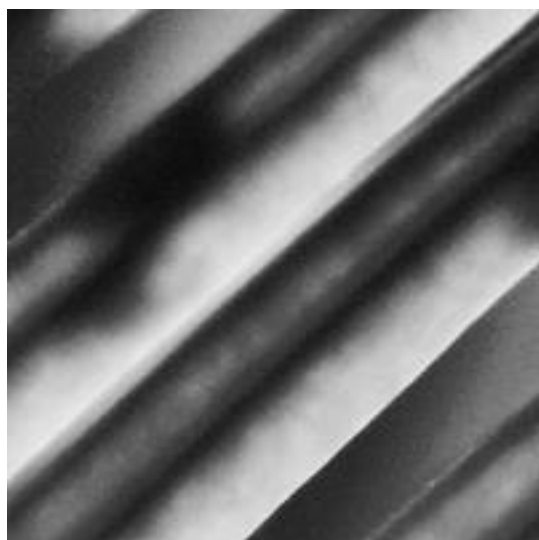
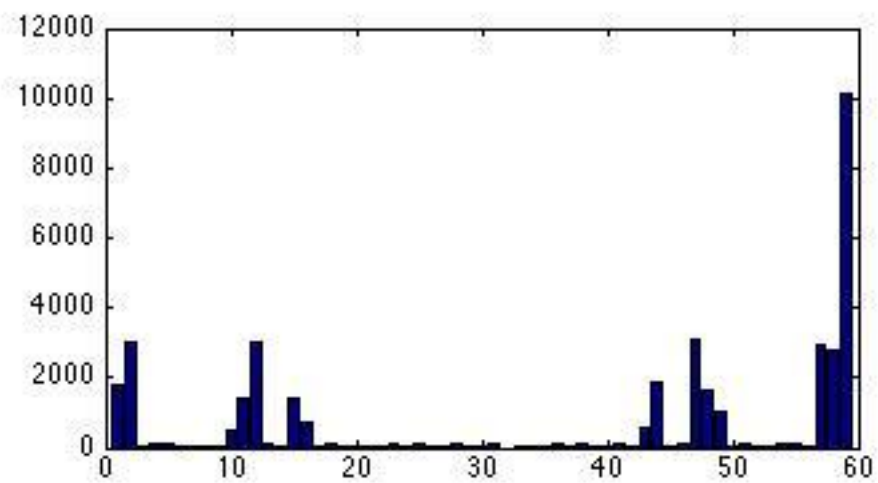
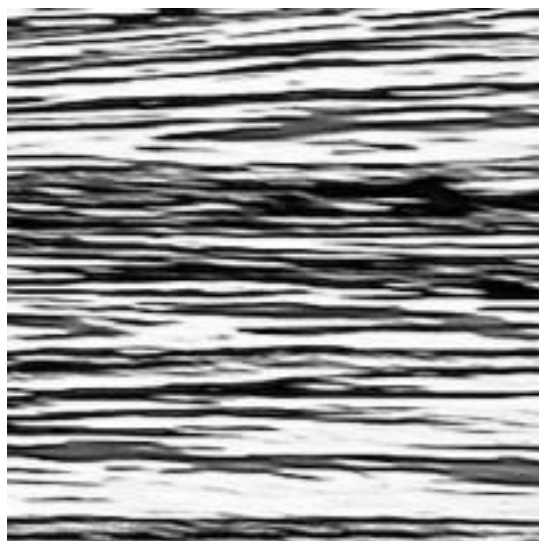
# Local Binary Patterns

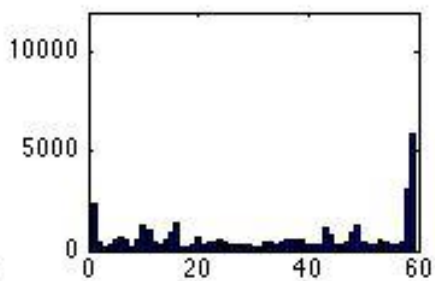
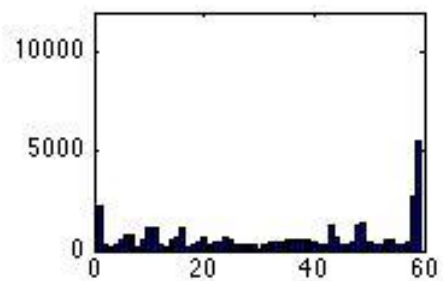
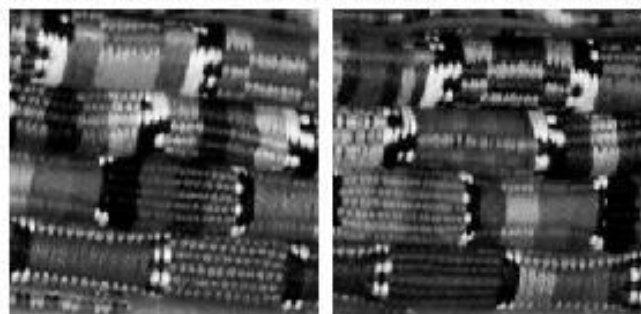
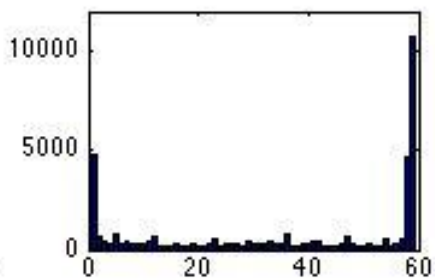
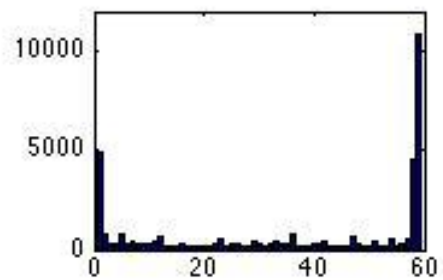
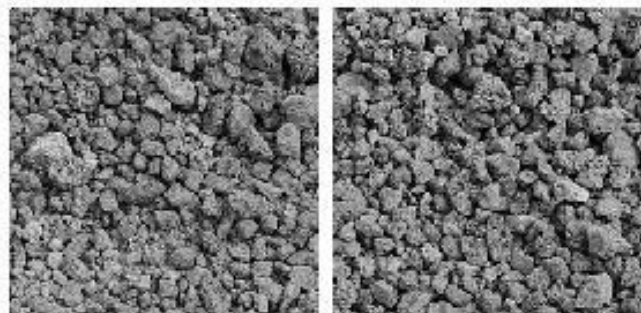
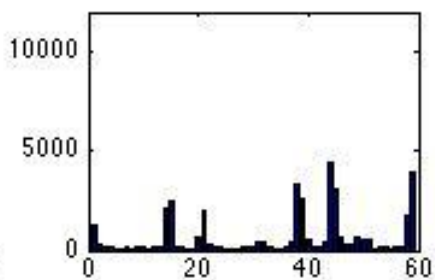
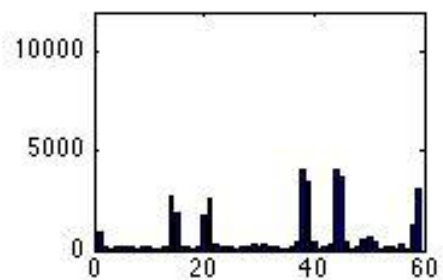
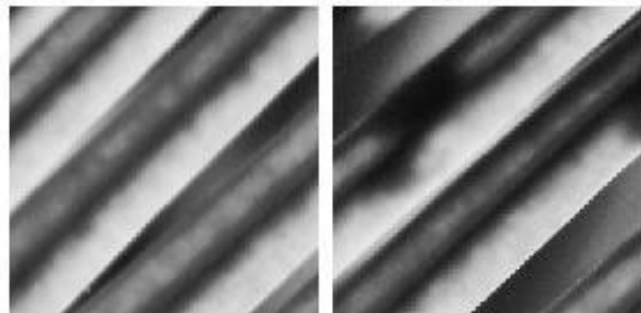
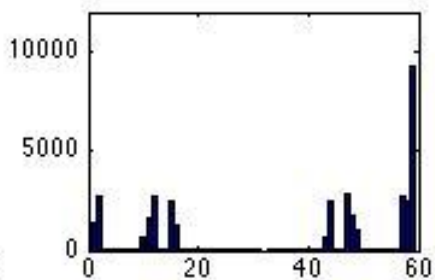
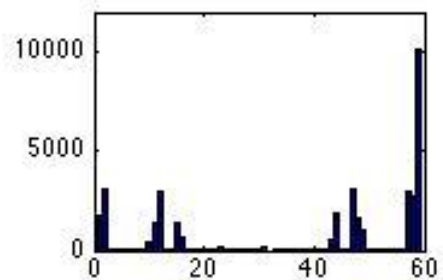
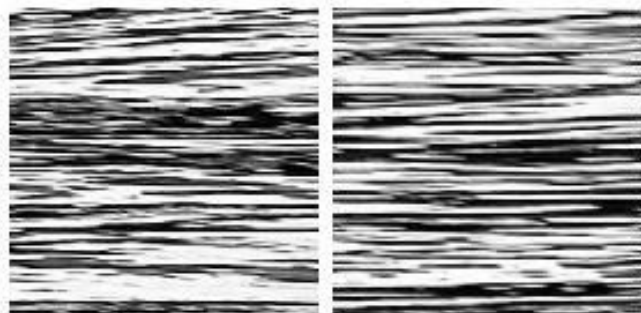
Examples  
Texture Images

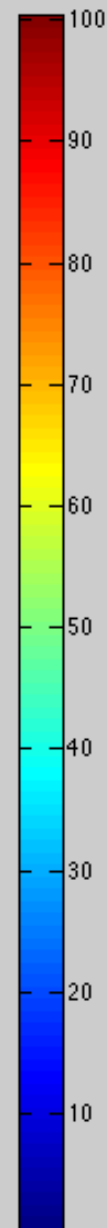
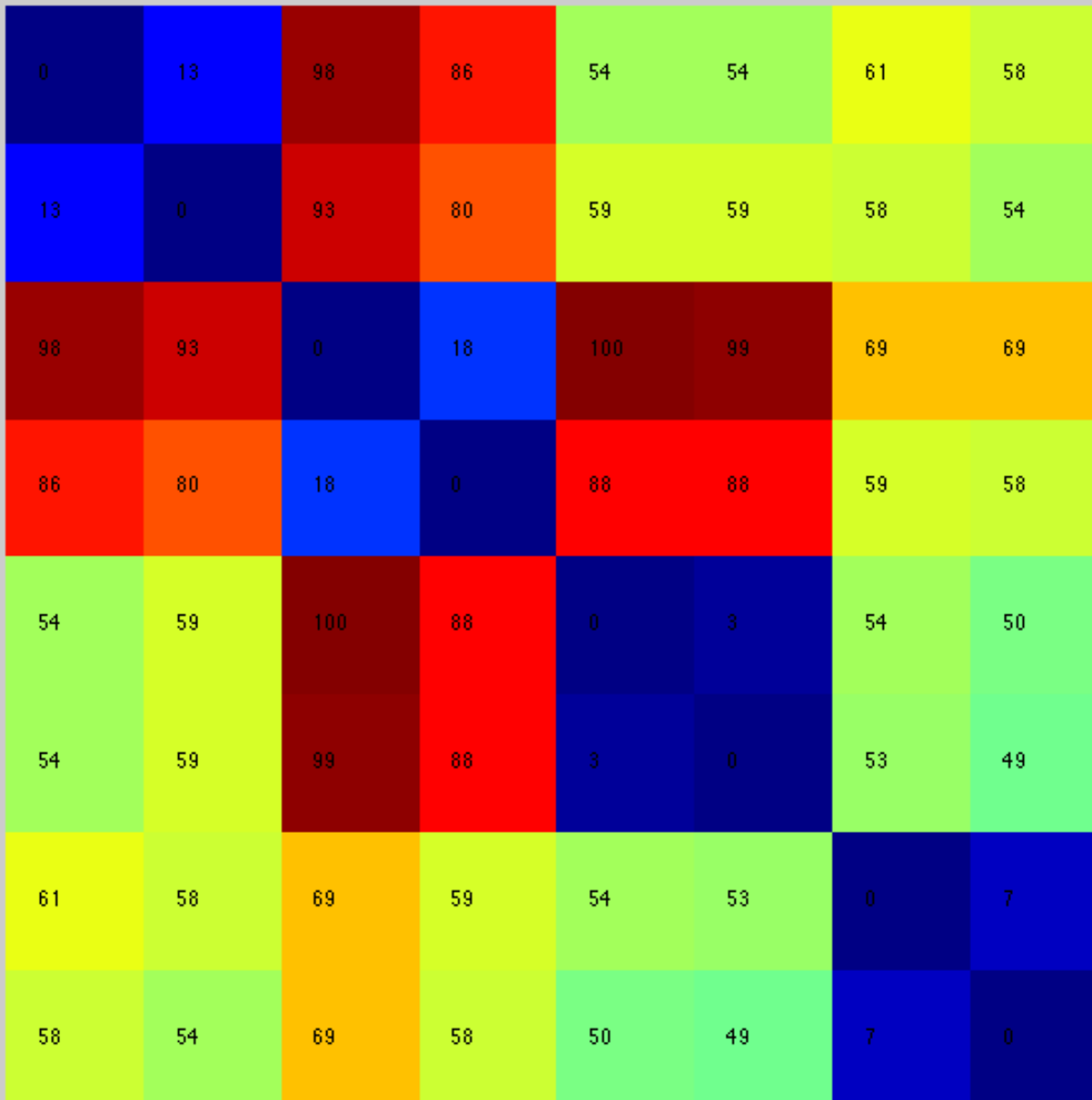
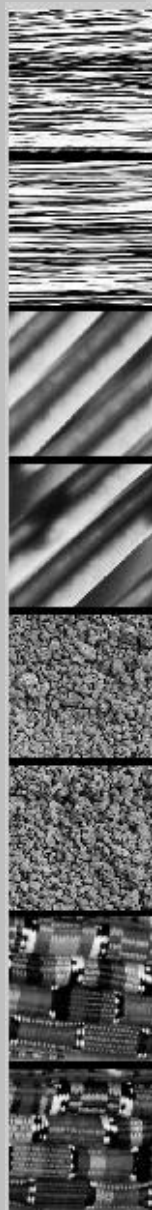
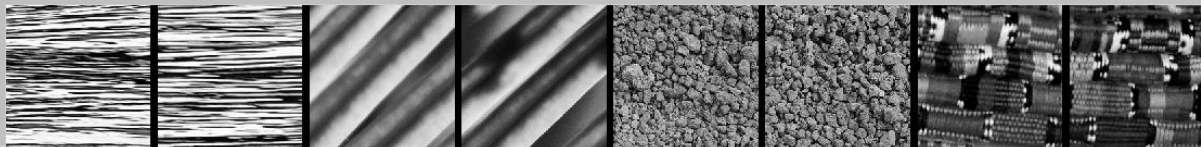












# Local Binary Patterns

Examples  
Face Recognition





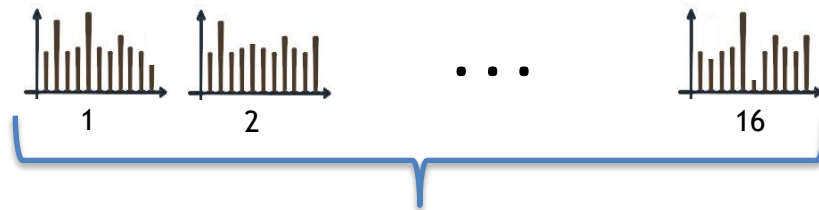
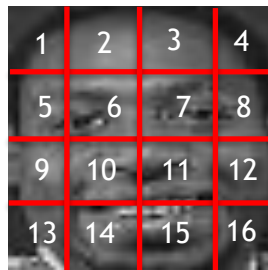
In the training set there are  $k$  classes.

For each class we have  $n$  training images.

In this example there are 40 classes with 9 images each.

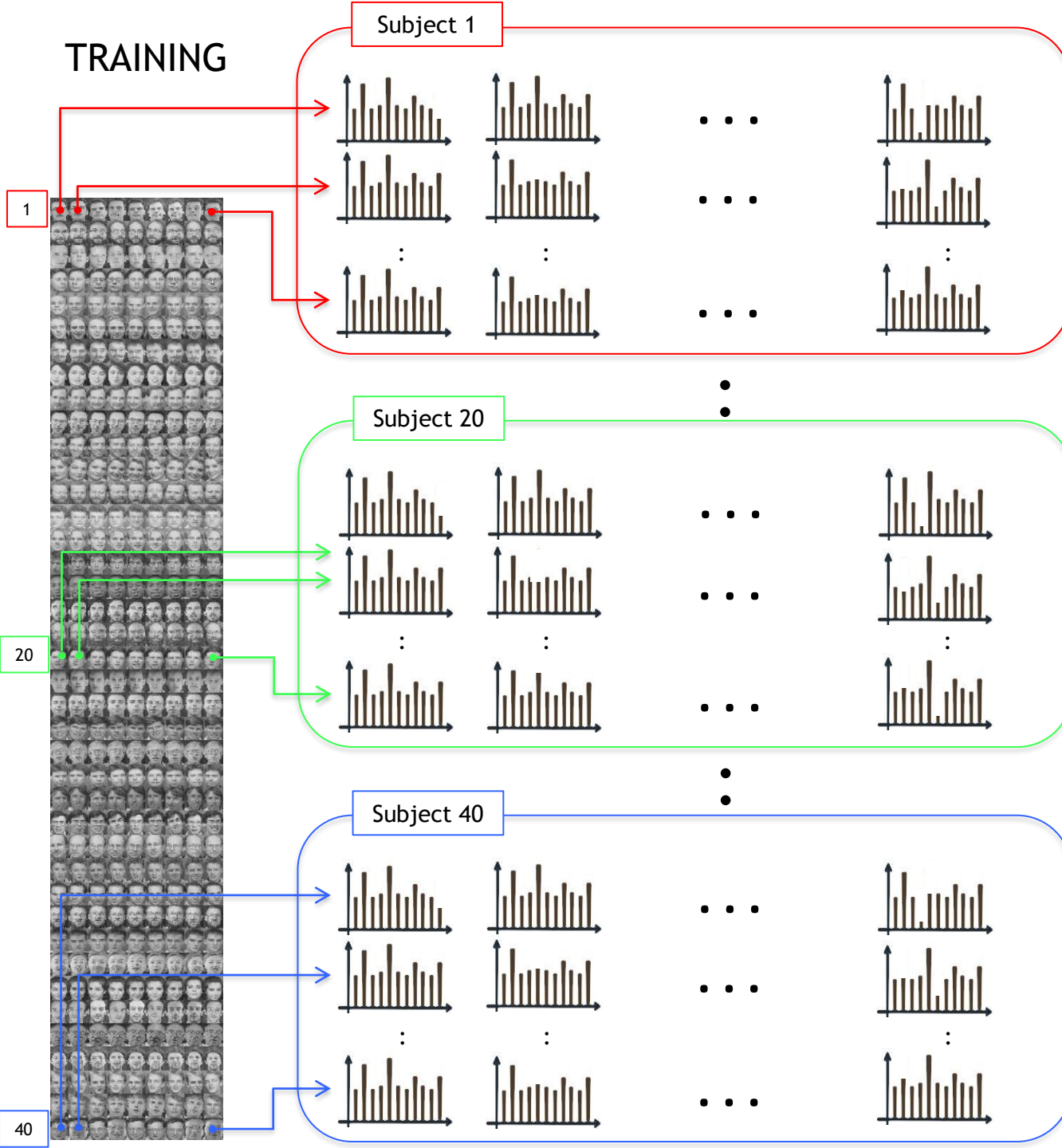
Each image we use  $w \times w$  partitions

In each partition we extract LBP feature



A face is described using a feature of  $16 \times 59 = 944$  elements

# TRAINING



Training Data:

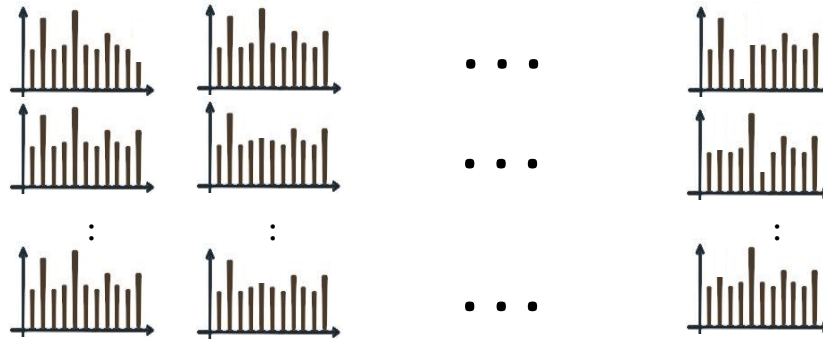
Table with:

$9 \times 40 = 360$  rows

$16 \times 59 = 944$  columns

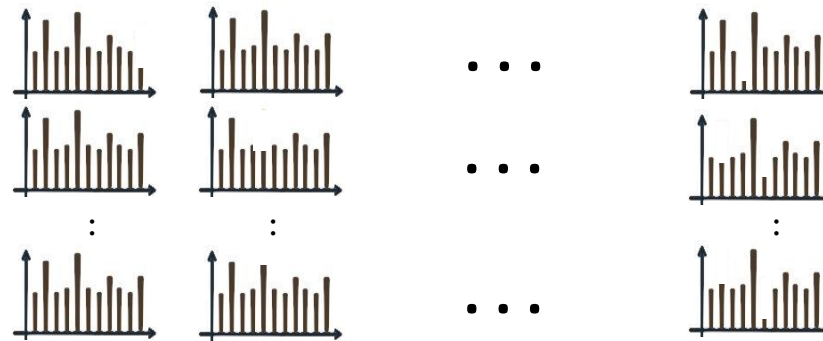


Subject 1



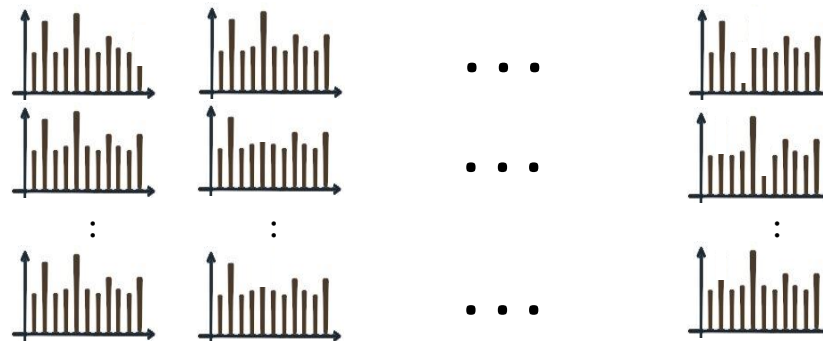
•  
•

Subject 20

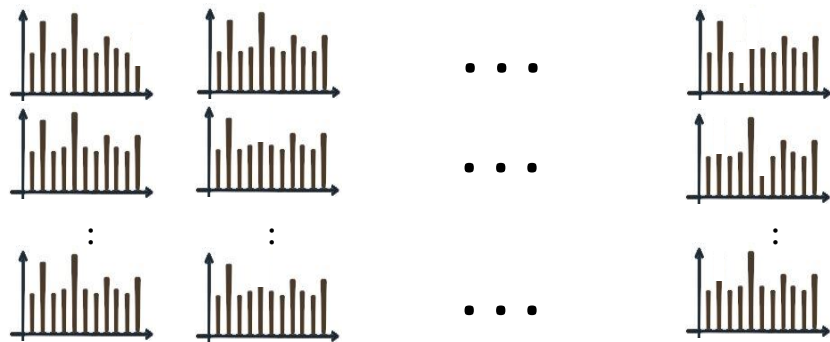


•  
•

Subject 40

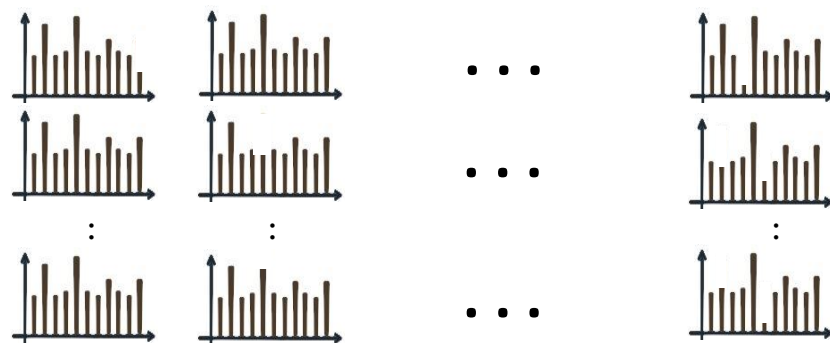


Subject 1



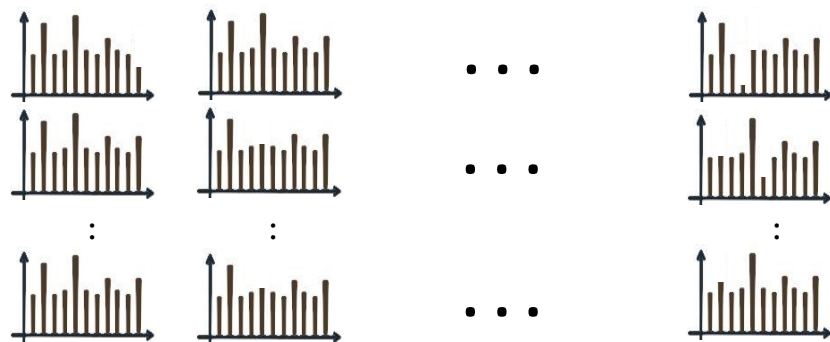
⋮

Subject 20

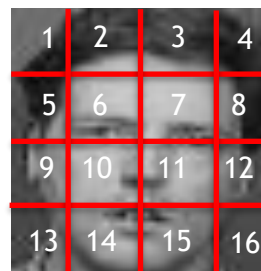


⋮

Subject 40



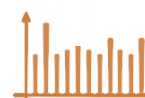
## TESTING



Who is this subject?



1



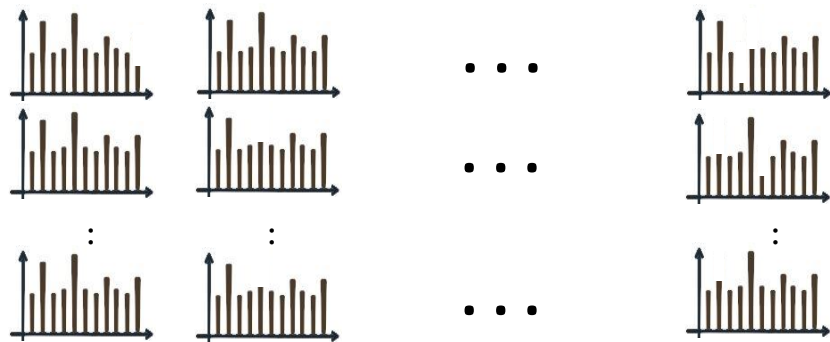
2

...

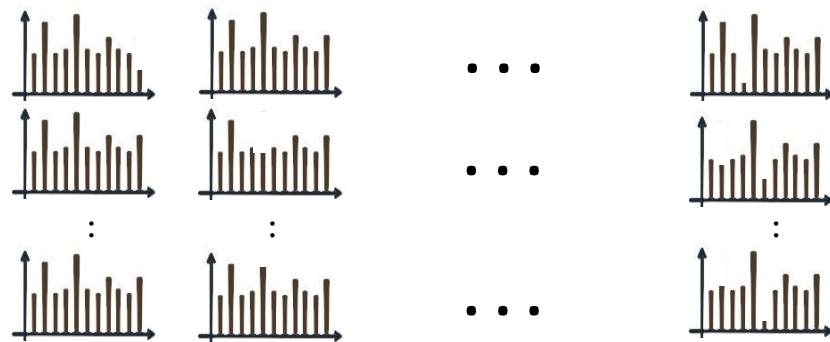


16

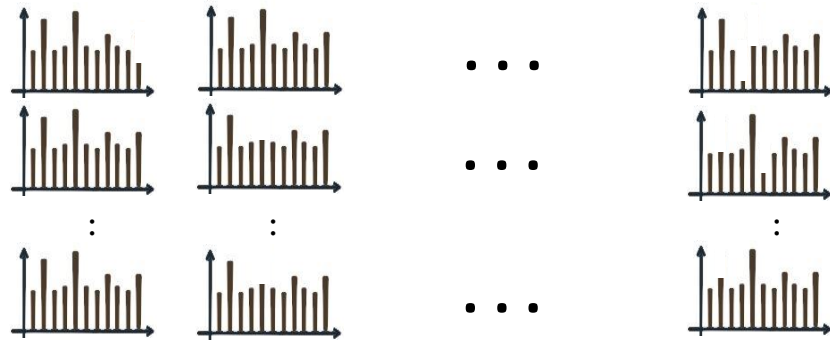
Subject 1



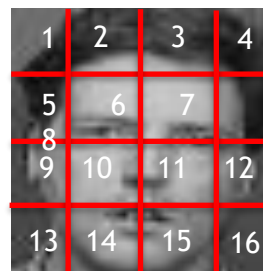
Subject 20



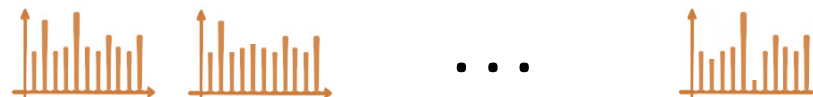
Subject 40



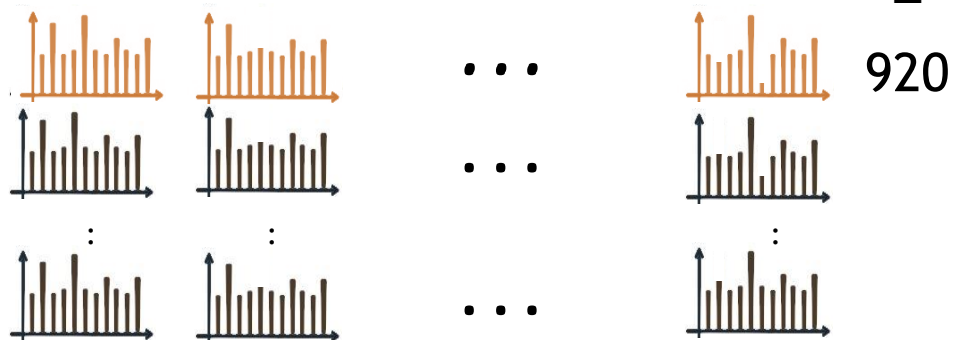
## TESTING



Who is this subject?



Subject 1

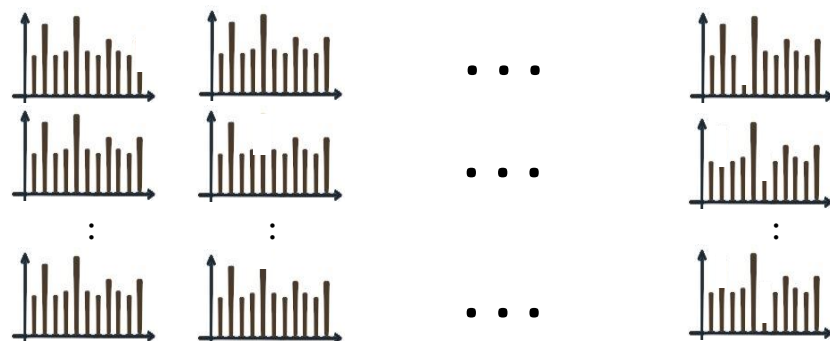


TESTING

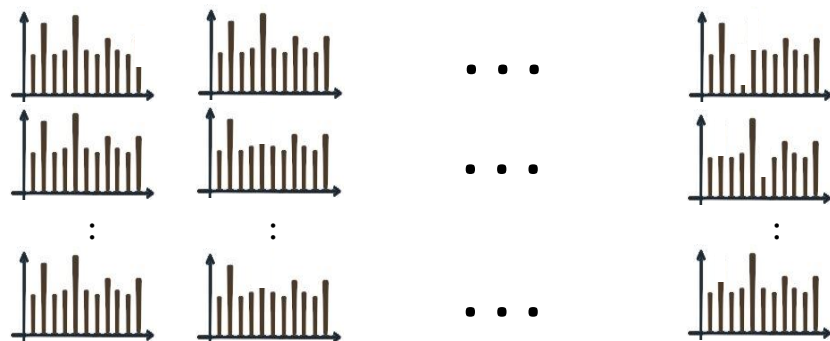


Who is this subject?

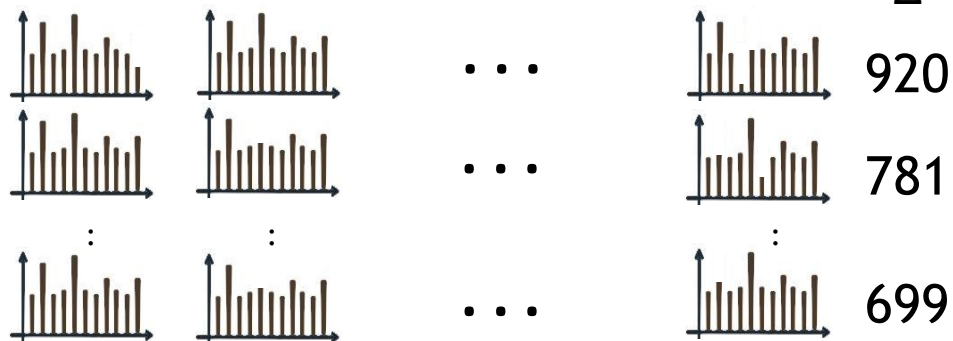
Subject 20



Subject 40



Subject 1

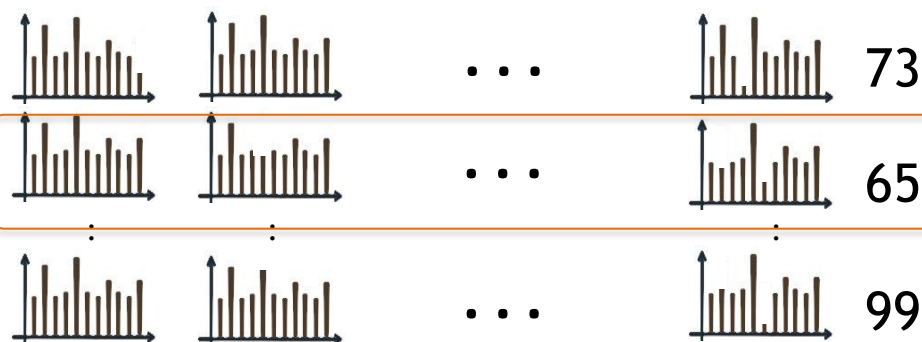


TESTING



Who is this subject?

Subject 20



Minimum

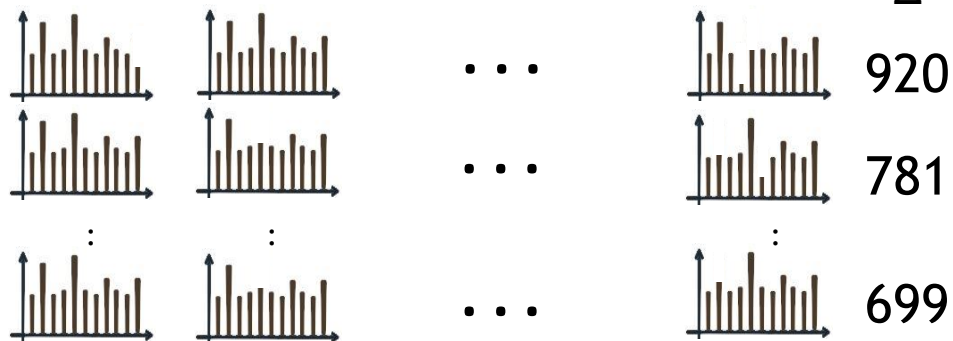
Subject 40



Strategy 1:  
*The nearest neighbor*

Strategy 2:  
k - nearest neighbors  
(knn)

Subject 1

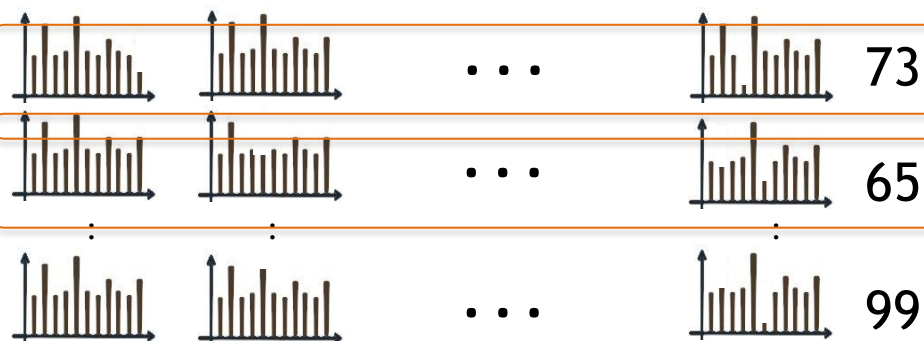
 $\Delta$ 

TESTING

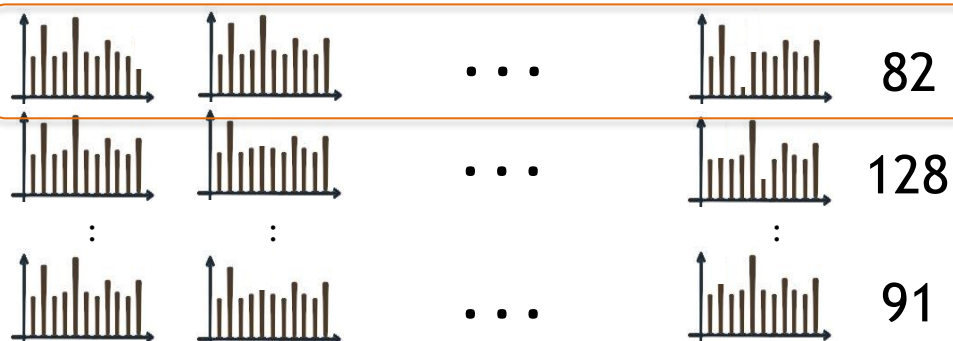


Who is this subject?

Subject 20



Subject 40

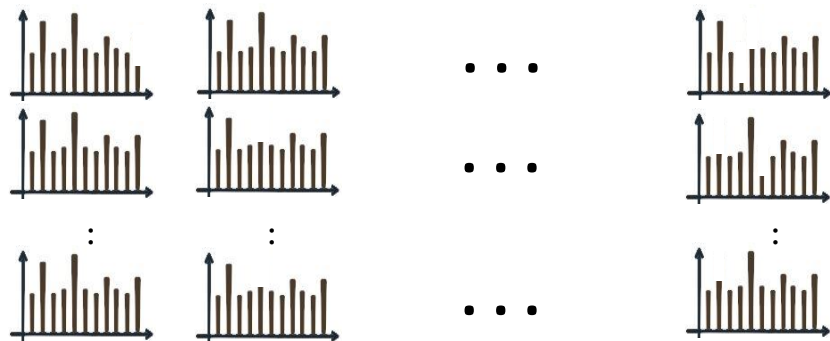
2<sup>nd</sup> Minimum > Subject 201<sup>st</sup> Minimum > Subject 203<sup>rd</sup> Minimum > Subject 40

Strategy 2:  
*k-nearest neighbor* (k=3)

Strategy 3:  
smallest sample-class  
distance



Subject 1

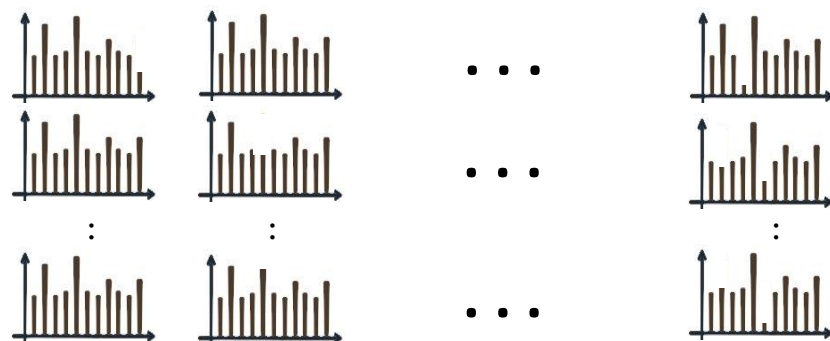


TESTING



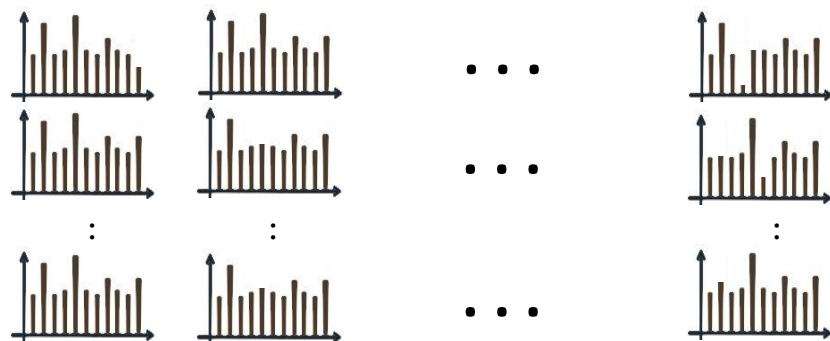
Who is this subject?

Subject 20

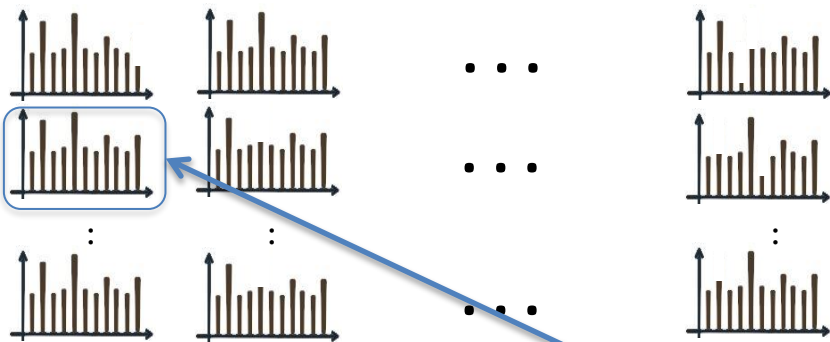


Minimal distance

Subject 40



Subject 1



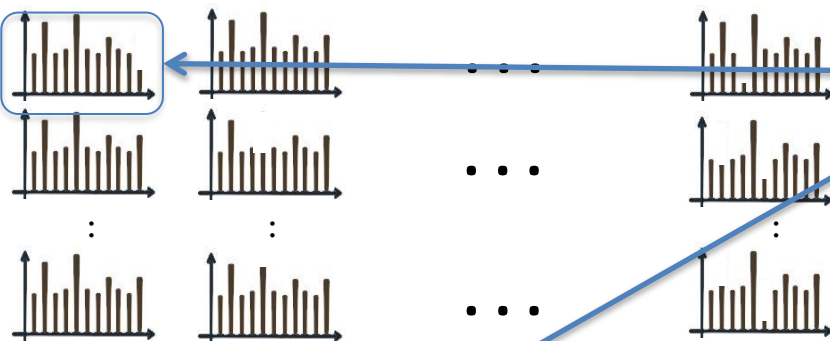
$\Delta$   
120

TESTING

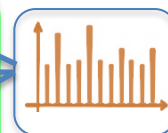


Who is this subject?

Subject 20



23

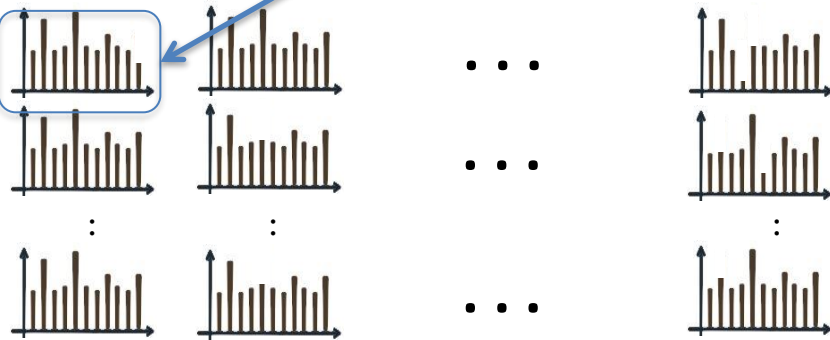


...



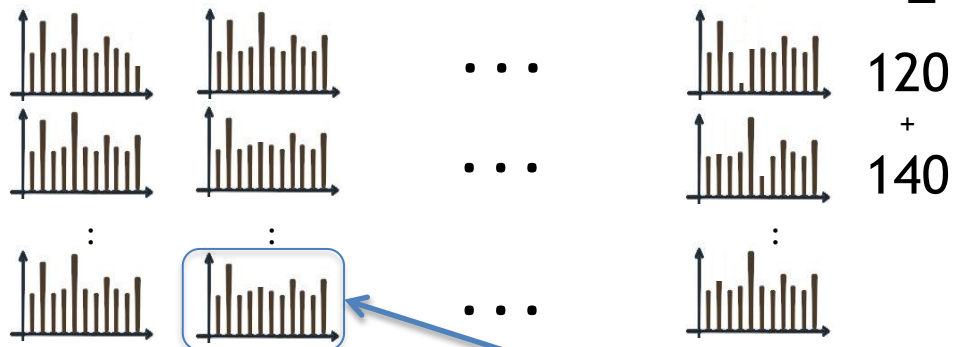
Minimal distance

Subject 40



12

Subject 1



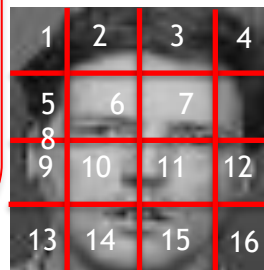
$\Delta$

120

+

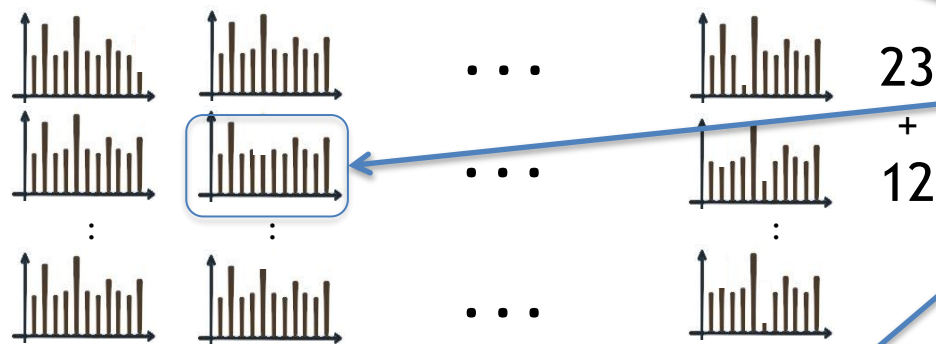
140

TESTING



Who is this subject?

Subject 20



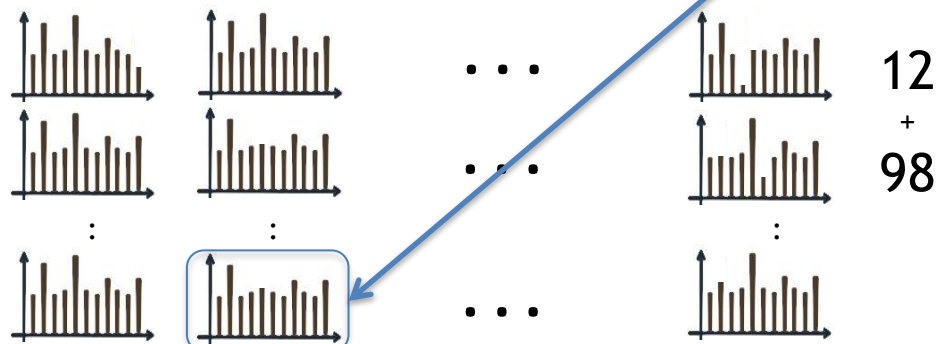
23

+

12

Minimal distance

Subject 40

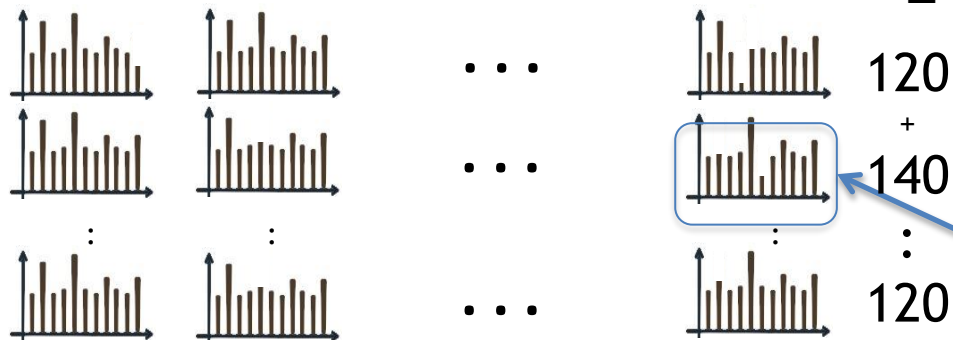


12

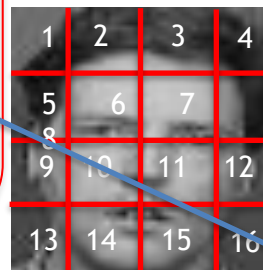
+

98

Subject 1

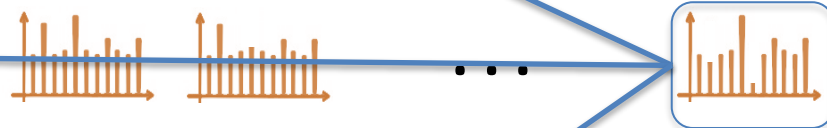


TESTING



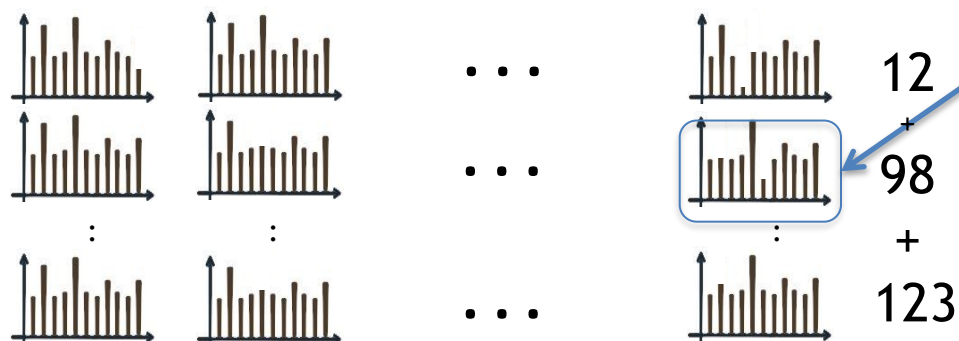
Who is this subject?

Subject 20

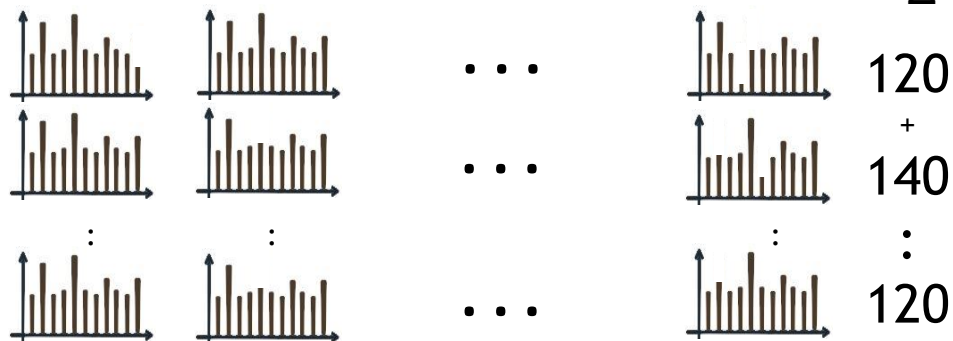


Minimal distance

Subject 40



Subject 1



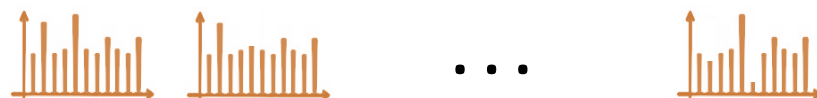
$\Delta$

TESTING



Who is this subject?

Subject 20



= 54

Minimal total distance

Subject 40

